2nd Generation NASA Sensors Working Group Workshop (GRC, 2002)

Sensors and Data Acquisition Development Efforts at KSC

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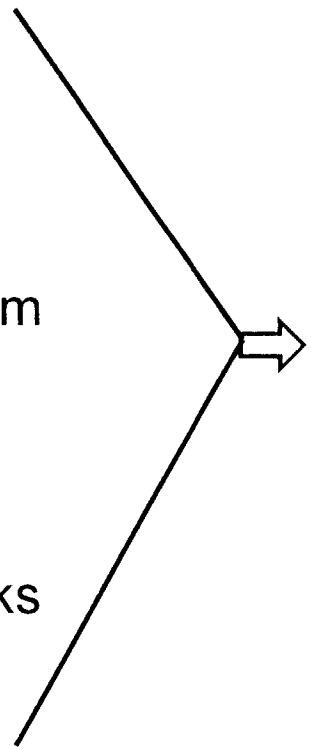
Program Needs

To reduce the cost to access space, advanced vehicles and ground support systems (launch pads) customers require sensors and instrumentation systems with the following characteristics:

* Low power requirements
* Reduced Weight/Size/Volume
* Low Maintenance/High Reliability
* Easily Incorporated to Vehicle/System
* Reduced Initial and operations cost
* Redundant/Fault Tolerant systems
* Capable to perform self health checks
* Provide information vs. raw data



Less ***$$*** per pound to fly

Outcome of Customer Needs Study

- A comprehensive study of Customer's needs, as well as present and near future innovative technologies, was performed by the Transducers And Data Acquisition Group at KSC in FY99.
- A long term plan for advanced sensors and data acquisition systems was generated.
- A internal roadmap was established to align to NASA Goals and Objectives and to address present and future vehicles and Ground systems needs.
- Plan also identified new and emerging technologies that are the best candidates to achieve the above goals.

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Long Term, Top Level Roadmap

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Advanced Sensors and Electronics

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Major Milestones & Decisions	Miniature MEMS sensors Current Signature	U.S.C.A Multi-Array Pressure Transducer		Wireless UV/IR Calibrator Capacitance Sensor	VJ sensor	Millimeter Wave Sensor	IVHM Data Acquisition Advanced Diagnostics & Remote Repair		Tech Demo	
Key Tasks	**SMART SENSORS DEVELOPMENT**									
	♦ 1 MULTI DISCIPLINE/MULTI-SENSORS									
	♦ 2 WIRELESS COMMUNICATION									
	♦ 3 NON-INVASIVE SENSORS									
	♦ 4 MINIATURIZATION OF SENSORS									
	SMART INSTRUMENTATION DEVELOPMENT									
	♦ 5 ADVANCED DATA ACQUISITION SYSTEMS									
	♦ 6 SELF HEALING ELECTRONICS									
	♦ 7 POWER MANAGEMENT									
	♦ 8 REMOTE/DISTRIBUTED PROCESSING									
	ADVANCED SOFTWARE ALGORITHMS									
	♦ 9 SELF CALIBRATION ALGORITHMS									
	♦ 10 AUTO CONFIGURATION/SELF HEALING ALGORITHMS									
	♦ 11 FAILURE ANALYSIS/TRENDING ALGORITHMS									
								TECHNOLOGY INTEGRATION AND DEMONSTRATION		**TECHNOLOGY IMPLEMENTATION**
Partners	Shuttle, Space Station, Payloads, Advanced Vehicles, JPL, MSFC, GRC									

Objectives

- 1 MEMS TECH.
- 2 WIRELESS COMM.
- 3 SMART ELECTRONICS
- 4 DISTRIBUTED PROCESS.
- 5 SMART SYSTEMS

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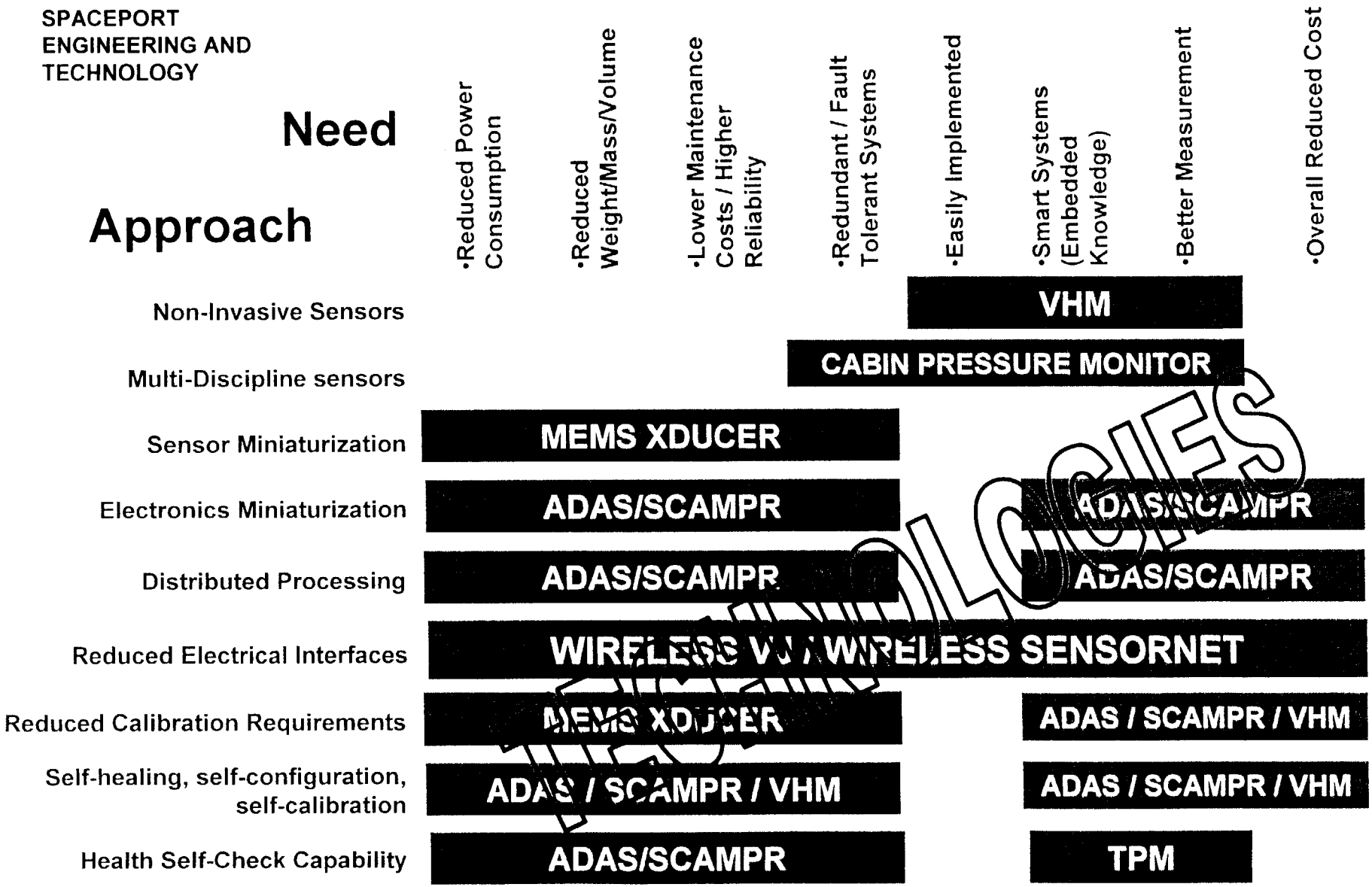

SMART SENSORS DEVELOPMENT

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Multi-Sensor Array (MSA) Transducers

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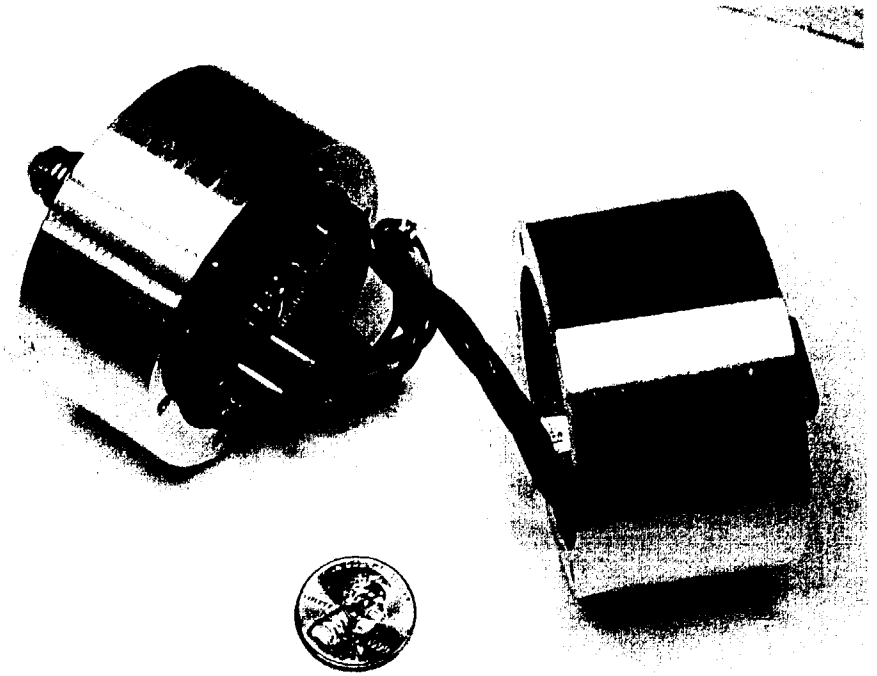
Objective

To develop a fault-tolerant transducer to achieve at least 3x present calibration cycle time and increase measurement reliability.



Design

Array of MEMS pressure sensors and proprietary software algorithms to achieve objectives. Electronics provide autonomous self-health checks.

Status

- Reliability studies conducted on 8-pressure transducers array.
- Software algorithms have been written and preliminary tested.
- Sensor Simulation has been performed to check software algorithm.
- Ruggedized prototype (8-element array) has been procured.
- Preliminary testing is being performed at this time.

Multi-Discipline Sensors Development

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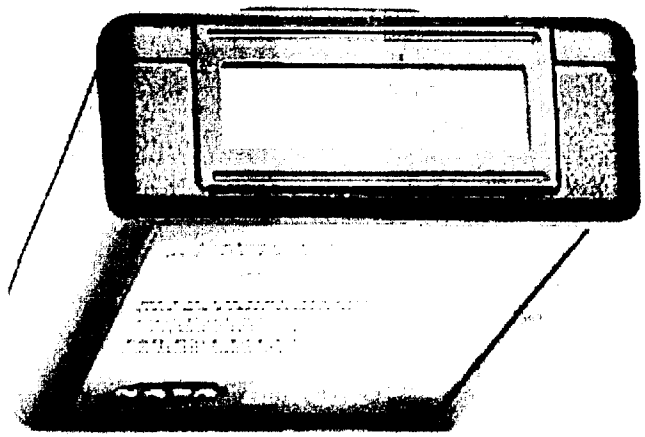
Objective

To develop multi-discipline sensors, integrated in a single package, configurable to the specific applications but designed flexible enough to accommodate diverse applications.



Status

- Developed a pager-size cabin pressure monitoring system. Design has been successfully transfer to industry.
- Stackable module-type design architecture has been designed.
- Generic modules are designed to perform common tasks to all applications, sensor-specific modules are designed for each application.
- Conceptual approach to incorporate CO_2 and O_2 to cabin pressure monitoring system is being studied.

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Wireless Sensors Network (*SensorsNet*)

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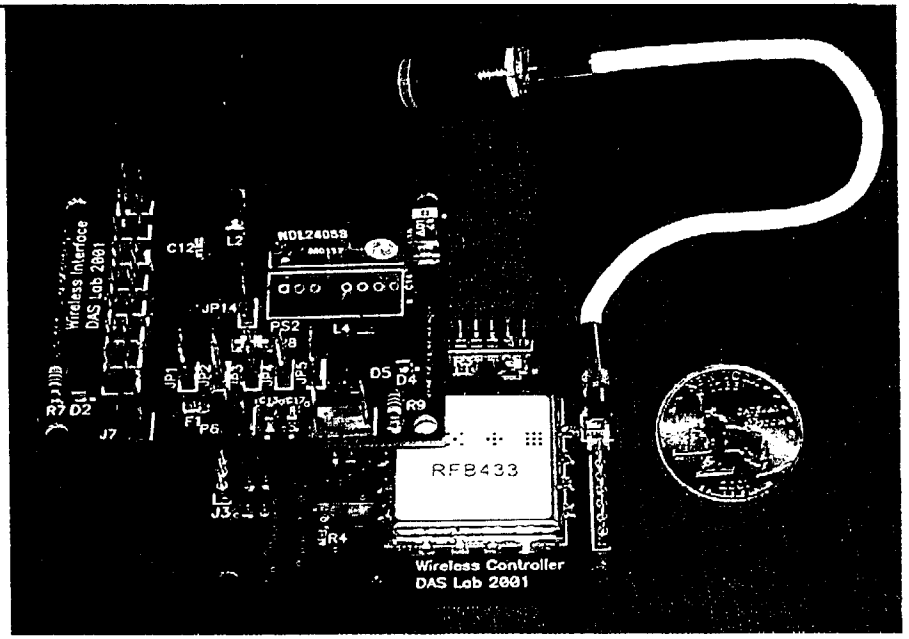
Objective

Design embedded wireless data link capability in sensors and transducers.

Create a robust sensor network architecture design (capable of autonomous or "on-demand" reconfiguration)

Provide sensor network with embedded process-specific intelligence.



Status

- Generic 433MHz RF Module, Power Management Module, Processor Module and Sensor Interface Module have been designed, prototyped and tested.
- Smart software algorithms to account for RF path problems (communication drop out) have been prototyped.
- Smart software algorithms for system's power management have been prototyped.
- Generic ideas in embedding process-specific knowledge in sensors are being studied at this time (information vs. data).

Vacuum Jacketed (VJ) Line Wireless Sensor

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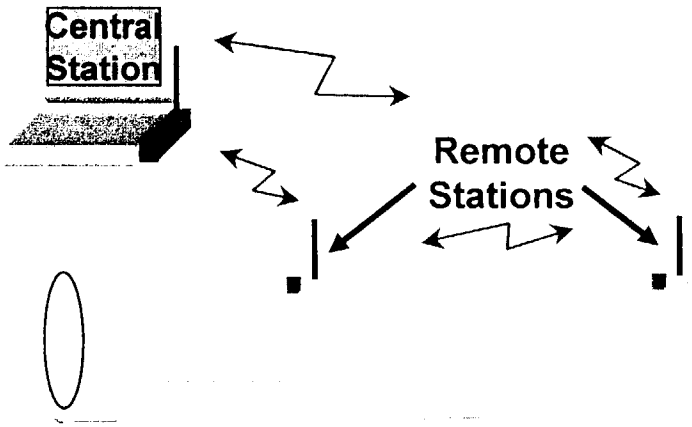
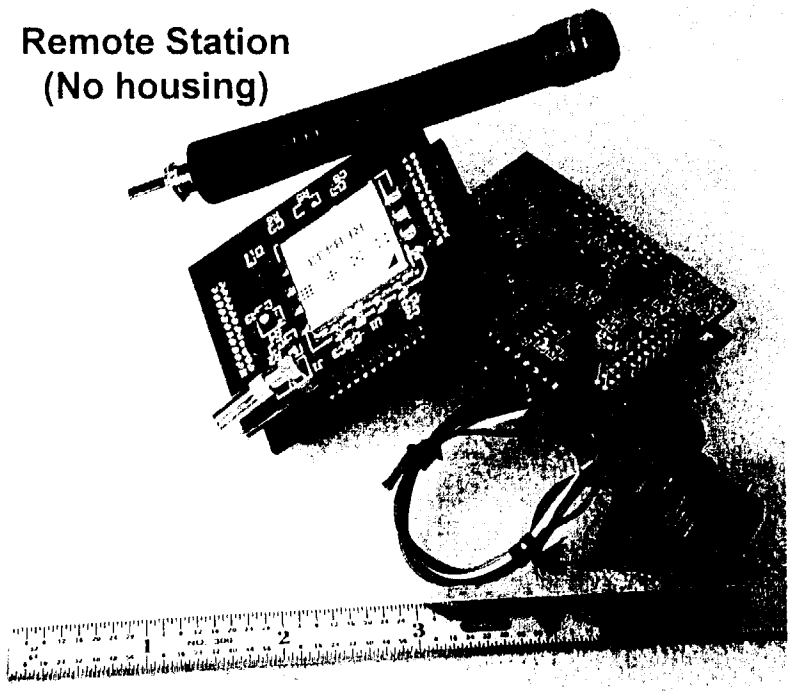
Objective

Provide the Launch Pads LH_2 and LO_x VJ lines with wireless sensors to autonomously monitor the conditions of the lines prior and during loading operations.



Status

- Operational requirements were developed with the customer.
- System conceptual design Architecture was completed.
- A Central Station with 10 Remote Stations are being prototyped with estimated system deployment on September 2002.
- Project was based on previous developments of the VJ Signal Conditioner (IVHM HTD project) and Wireless Sensor Network project.



Valve Health Monitor (Current Signature)

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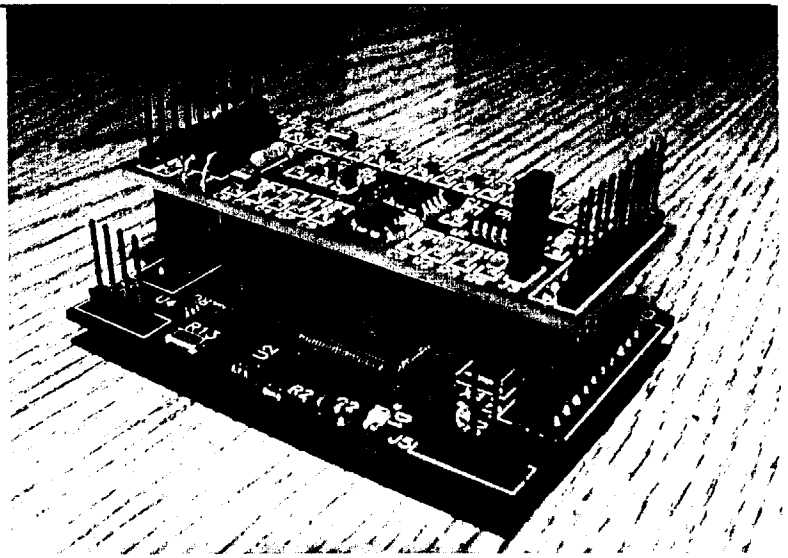
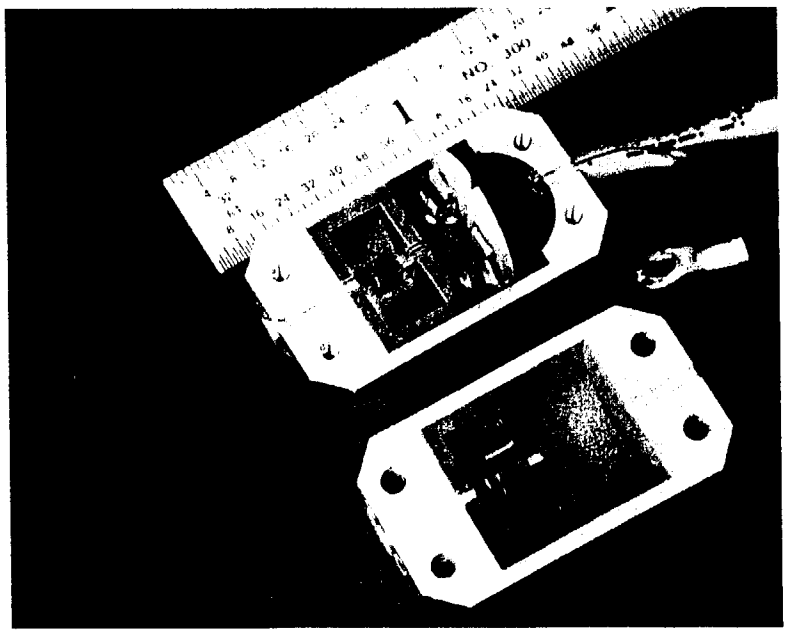
Objective

Develop non-invasive sensors, with embedded process-knowledge capability to detect and ultimately predict system's failures and/or degradation before they happen (failure trending and prediction)

Status

- Prototype of Current signature sensor (analog, digital and power modules) has been designed, fabricated, and preliminary tested.
- Preliminary Smart software algorithms to detect failures and/or degradation under different external conditions have been developed and preliminary tested.





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Hurricane Wind Sensors Development

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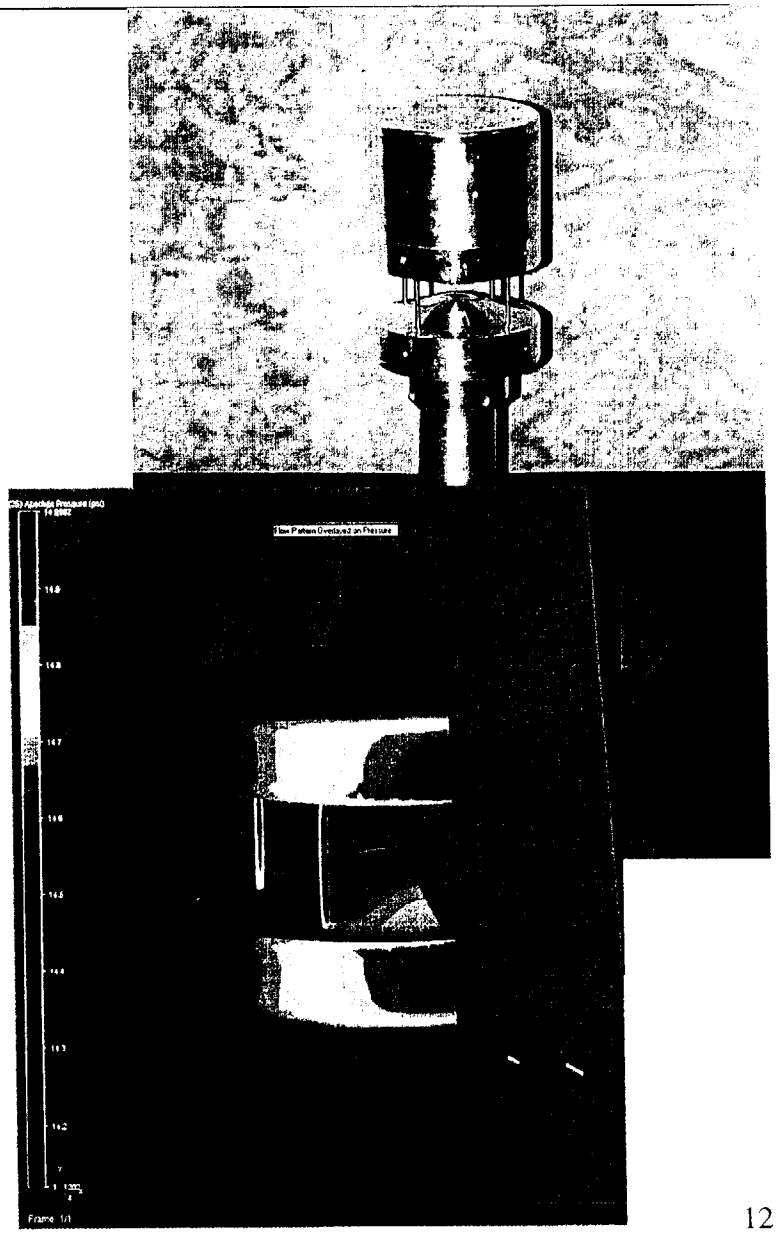
Objective

Provide KSC with a rugged, low profile, high reliable, self-contained wind speed and direction sensor to measure wind speeds up to 300 mph. Project involves multi-discipline sensor technology combined with smart software algorithms.

Status

- A 3-D Venturi Wind Sensor has been designed, developed, fabricated and is being tested at the present time.
- Wind Sensor has been modeled and computer simulation has been performed using CFD software.
- Self -contained electronics has been designed and initial testing performed.
- Testing of sensor at Embry Riddle Aeronautical University (ERAU) is scheduled for later this year.



SMART INSTRUMENTATION DEVELOPMENT AND SMART SOFTWARE ALGORITHMS

Advanced Data Acquisition System (ADAS)

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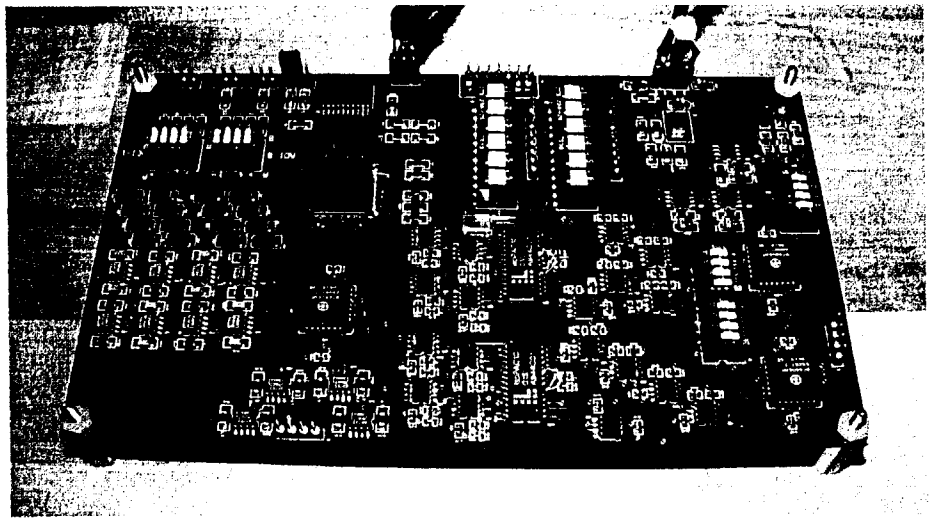
Objective

Develop a data acquisition system that incorporates self-health checks, self-calibrating, self-healing capabilities, and allow for greater measurement reliability with minimum number of component redundancy.



Status

- A conceptual design architecture of the system was developed and baselined.
- An ADAS prototype has been designed, developed, fabricated and preliminary tested with the above mentioned requirements. System is modularized containing an analog module, a digital/control/communication module, and a power management module.
- Smart software algorithms has been developed to allow automatically re-route of signals through different paths in the system when the processor identifies a component malfunction or degradation.

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SIGNAL CONDITIONING AMPLIFIER RECORDER (SCAMPR)

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Objective

Develop an improved ground measurement data acquisition system (DAS).

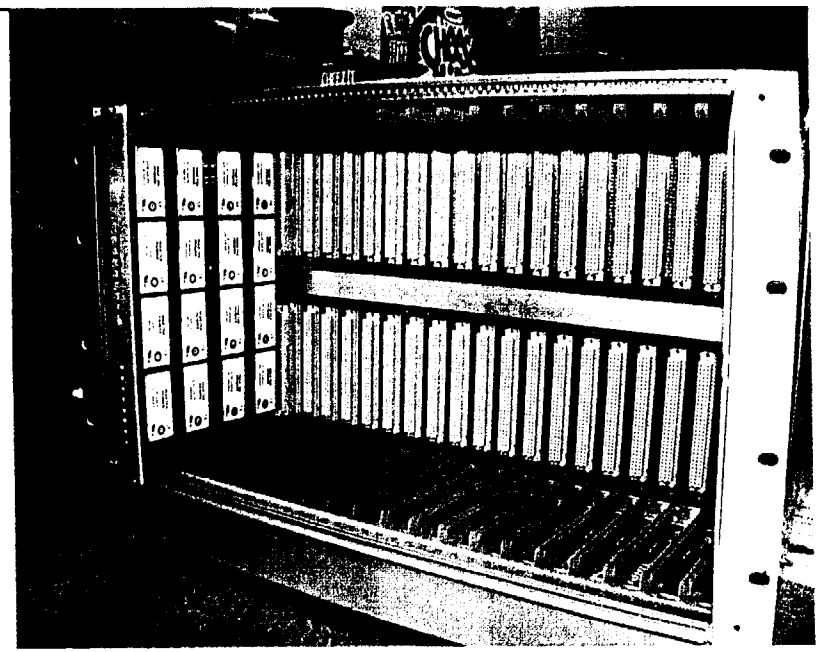
Design

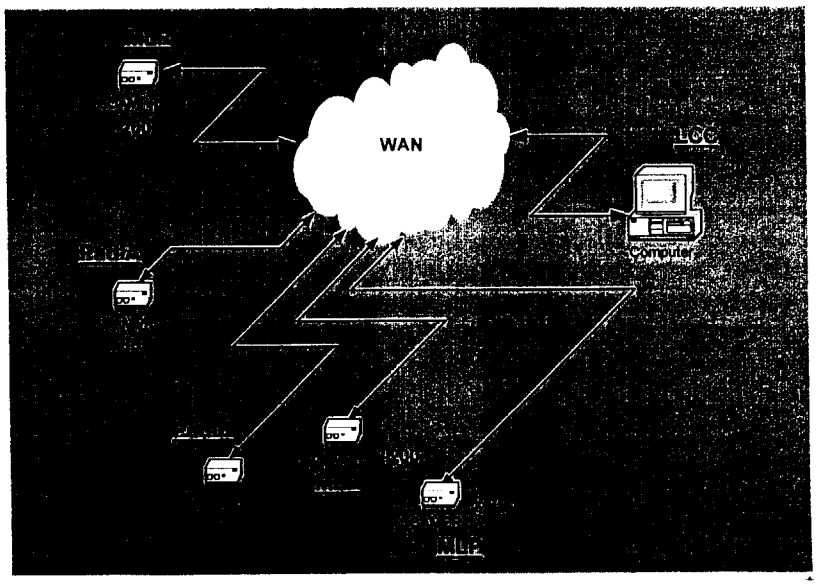
Backbone of new system is the Signal Conditioning Amplifier and Recorder (SCAMPR). It is a 16 channels/card, user-defined sampling rate, remote data storage, data time-stamping capable, with Ethernet communication.

Designed to greatly improve reliability, reduce cost of ownership (no proprietary software), and provide greater flexibility than existing ground measurement systems.

Status

- Design Requirements are being reviewed.
- Conceptual Design is being developed at this time.





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EMBEDDED PROCESS-KNOWLEDGE IN WIRELESS SENSORNET

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Objective

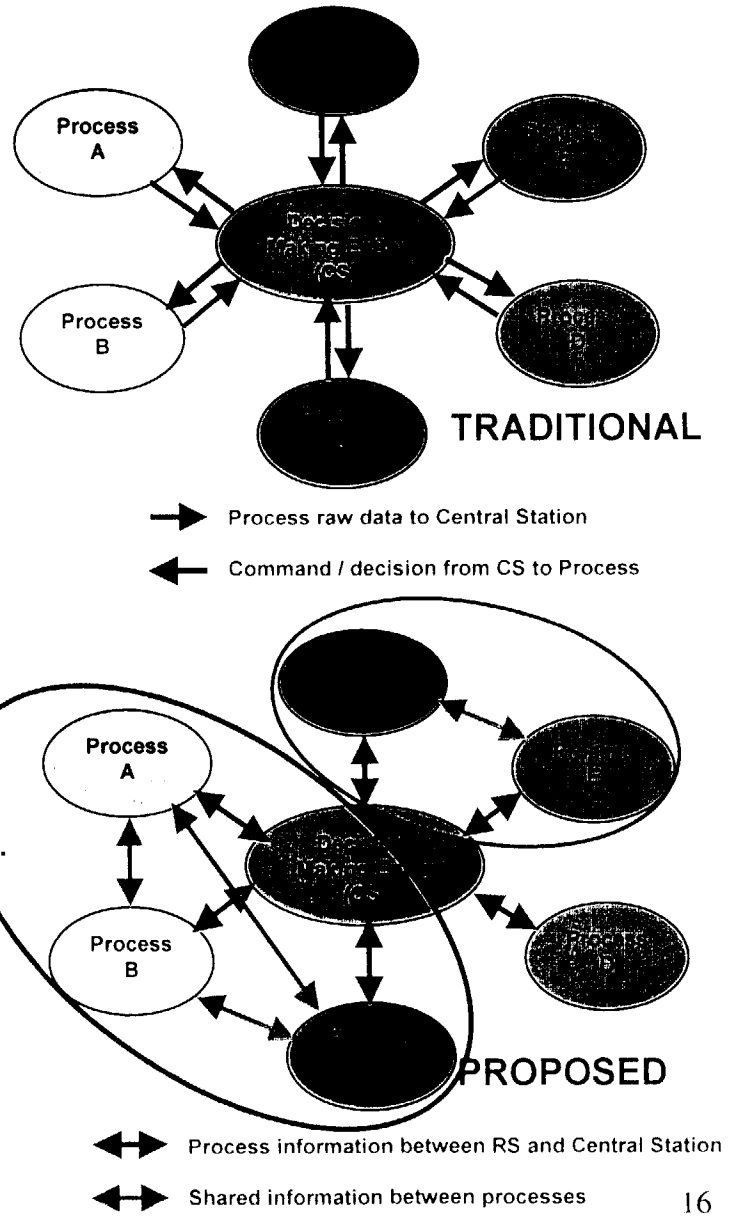
Design intelligent sensor network with embedded process-knowledge at the sensor level. De-centralize process decision making.

Design

- Complex processes broken down into simpler, smaller processes. Relationship rules are created to link all processes to overall process.
- Share process knowledge/information among sensors and controlling equipment via wireless communication.
- Process health monitoring done through individual sensor performance and process knowledge rules.

Status

- Process composed of 2 sub-processes and 6 measurements have been modeled and implemented. Testing is being performed at this time.



SMART TOOLS DEVELOPMENT

Orbiter Tire Pressure Monitor (TPM)

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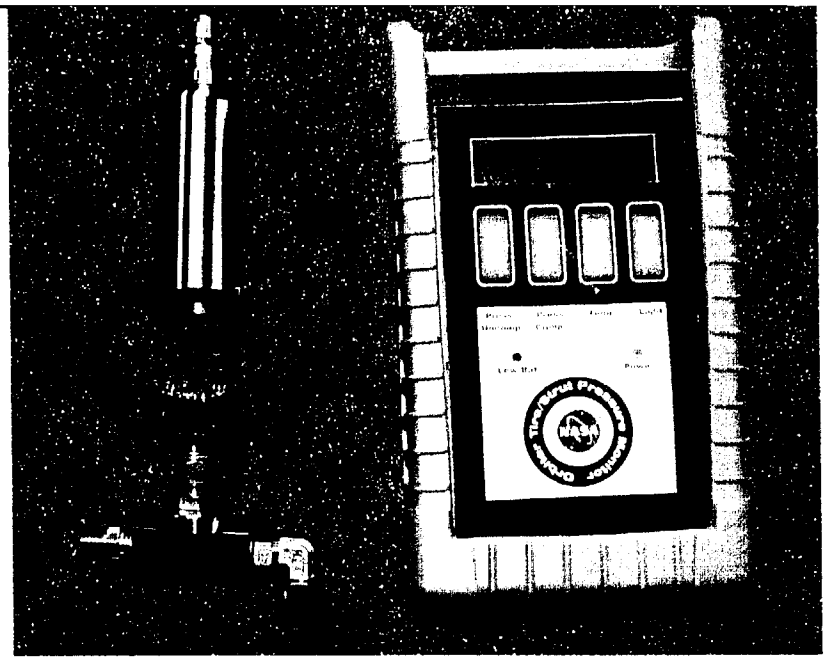
TECHNOLOGY

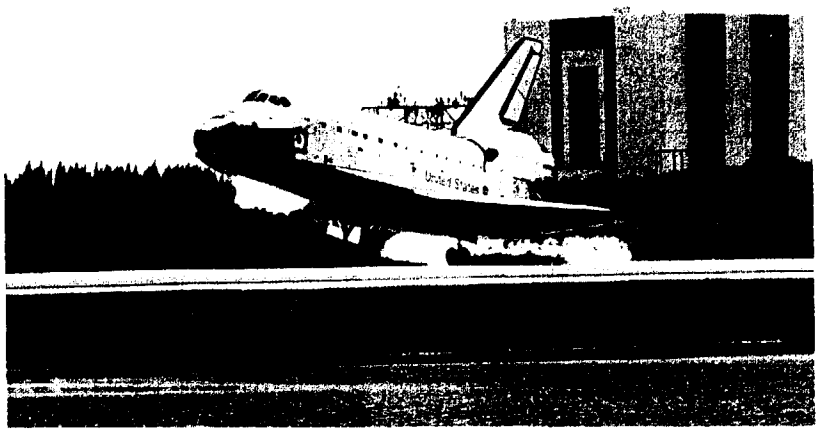
Objective

Develop a ground support equipment (GSE) device to monitor and certify the Orbiter tire and strut pressure for flight. System shall be capable to accurately measure 0.1 psi changes on a 400 psi static pressure.

Status

- System was designed using highly accurate pressure and temperature sensors and smart compensation software algorithm.
- Initial prototypes of the device have been designed, fabricated, tested and calibrated.
- Software algorithms have been developed and preliminary tested.
- Automated calibration station is being designed at this time.





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ET Centering and Alignment (ET CAS) System

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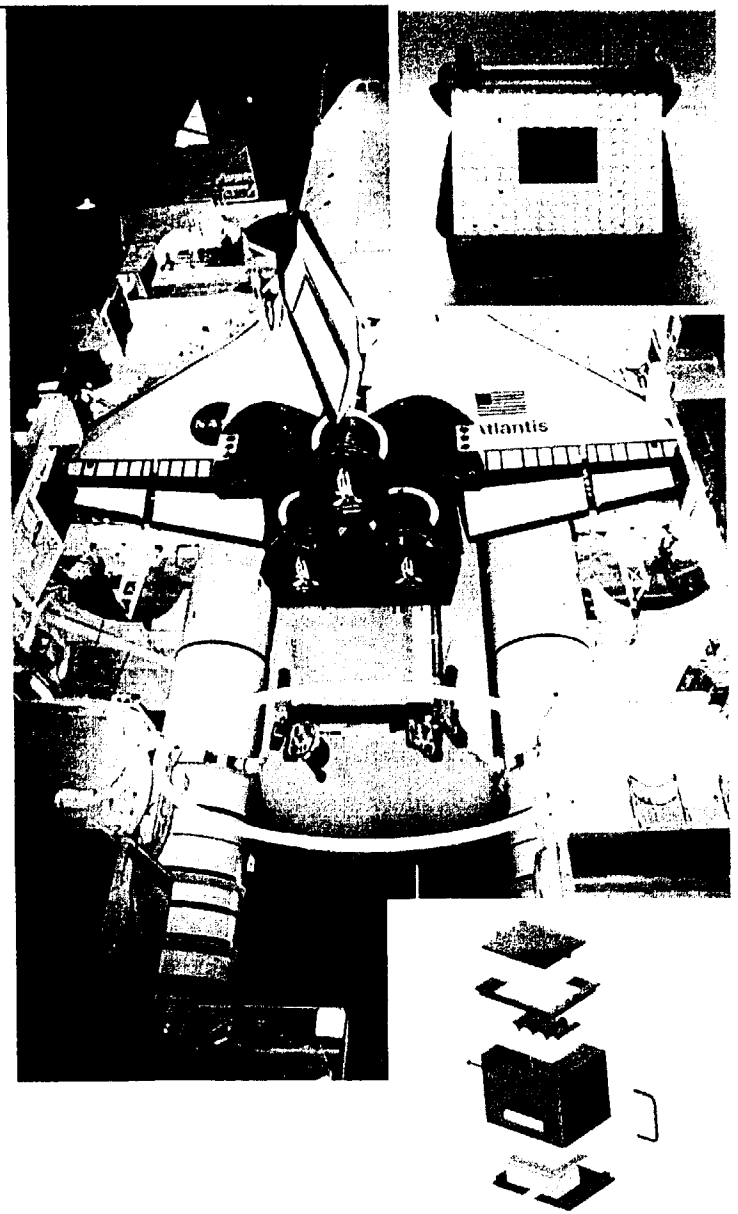
Objective

Develop an accurate alignment/centering tool to align the External Tank (ET) with respect to Solid Rocket Boosters (SRB) during ET/SRB mating. Provide automated distance measurement accurate to 0.01" between ET and SRB.

Status

Designed and fabricated New ET CAS.

- COTS laser sensors with capable accuracy.
- Two wireless sensing systems and a User Interface Console.
- Measurements are temperature compensated for temperature range (20 °F to 120 °F).
- Power management algorithm developed to enhance tool usage.
- System has greater accuracy with no calibration.



TESTING CAPABILITIES

2nd Gen. Mini Smart Leak Sensor

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This is a joint effort Between MSFC, KSC, GRC and MAKEL.

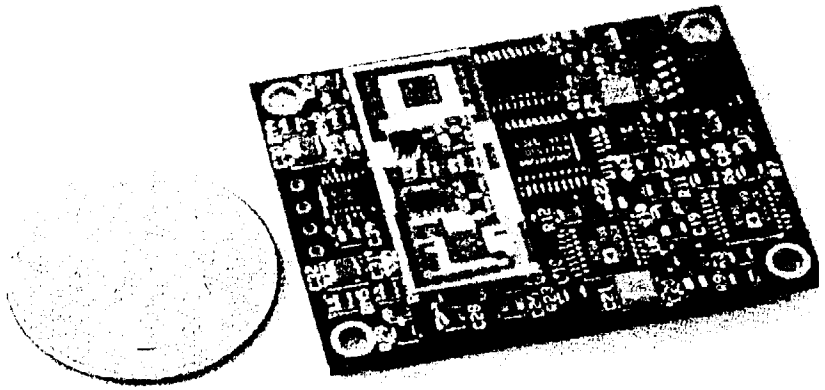
KSC Objectives

KSC will provide technical expertise in the transition of sensors developed by GRC into units suitable for aerospace application. KSC will perform all the necessary environmental testing required by flight vehicles, as well as materials compatibility analysis. Furthermore, KSC will provide technical feedback to GRC to aid in the achievement of the final product.

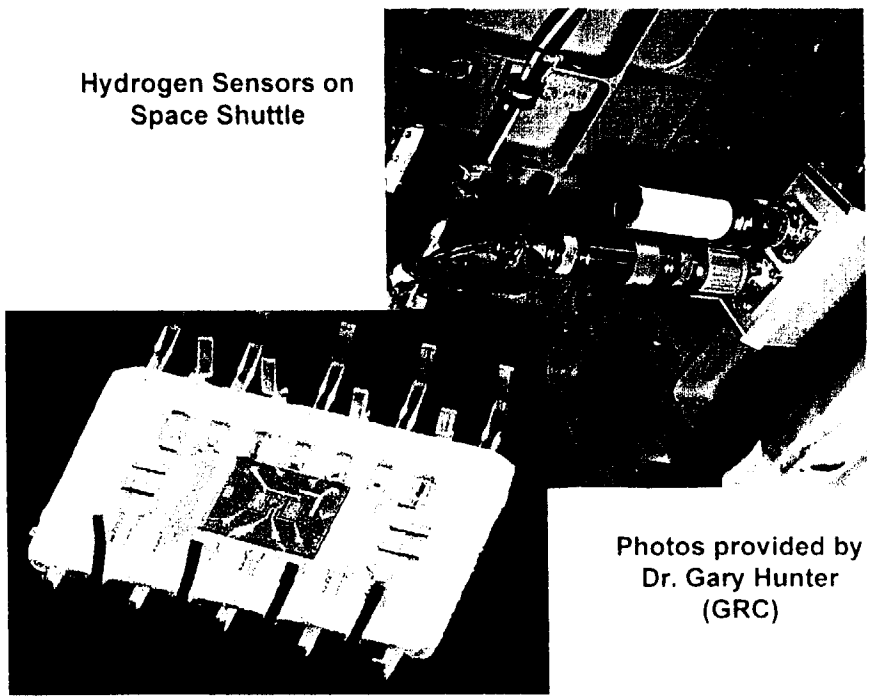
Status

- KSC has completed preliminary requirements.
- First set of prototypes have been preliminary tested.

Prototype Hydrogen/Oxygen Sensor System with Electronics



Hydrogen Sensors on Space Shuttle



Photos provided by Dr. Gary Hunter (GRC)

Micro-fabricated Hydrogen Sensor

Generic Testing Capability

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•Expertise in the areas of temperature, pressure, flow, acceleration, gas leak detection, flame detection, voltage/current sensing, load/force measurements and data acquisition systems among others.

•Qualification testing capability to Program requirements: functional testing, mechanical inspection and compliance, materials compatibility, environmental testing (vibration, EMI/EMC testing, thermal and thermal-vacuum testing, shock testing, etc) and long duration testing.

•Quick response technical support to Programs in the resolution of instrumentation problems as well as technical support to external customers (either NASA centers, contractors and/or universities).

Capabilities

•Temperature testing capability in the range from 15 Kelvin (-432°F) to 700 Kelvin (800 °F).

•Pressure testing capability for differential, absolute, and gage transducers from near vacuum (0.10 mTorr) to high pressure (2,000psig).

•Flow testing capability for both gas and liquids. Gas range from 0.2L/min. to 260 L/min. Liquid flow range from 0.1 gpm to 320 gpm.

•EMI screening capability for sensors and data acquisition systems to verify Electromagnetic Compatibility (EMC).

•Load and Force testing capability.

•Hydrogen leak detection testing capability.

•Burn testing area for Flame detectors. capable of hydrogen, alcohols and hypergol burns.

Generic Testing Capability

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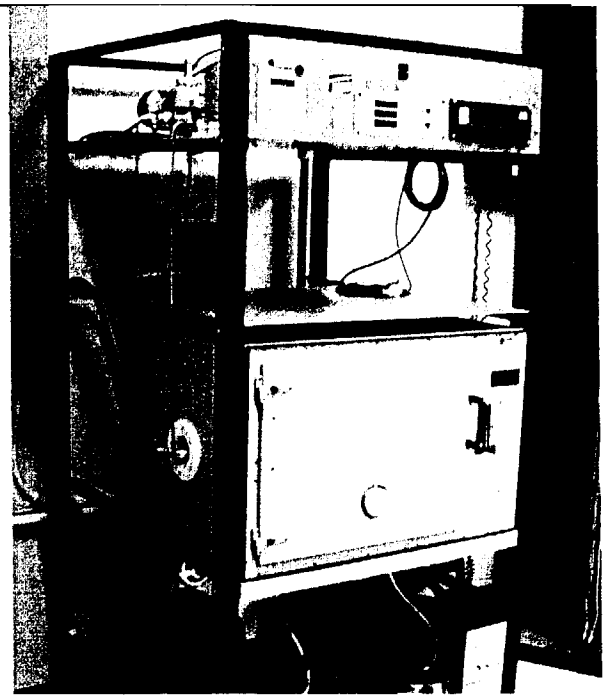
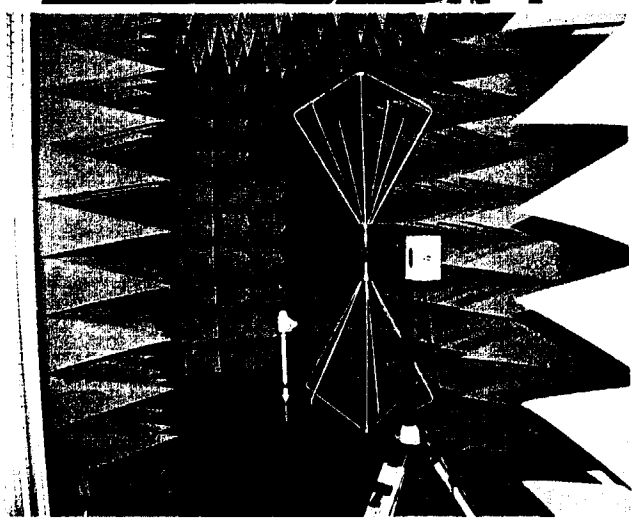
Capabilities (continued)

- Altitude Chamber testing capability for combined pressure, temperature and mixed gases testing of transducers.
- Gas mixing capability for five and eight different gases. Mass spectrometer capability to quantify gas mixture concentration.
- Software simulation tools (Computational Fluid Dynamics –CFD- software) for the simulation of gas flow behavior.
- CAD design of electrical schematic and PCB layout routing.
- PCB milling machine for the creation of in-house prototypes.
- Surface mount soldering capability for the fabrication of prototypes.
- Software development systems for the generation of firmware and software programs.





Other projects

Other projects

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- Micro-sensor for Logistics Applications (RFID)
- LOX Quantity Sensor
- LOX Magnetic Transport
- Advanced Lightning Measurements (SOLLO, etc)
- Intelligent Vision Systems and Anomaly Detection
- Tile Moisture Sensor
- Gas Sensors for Advanced Umbilicals
- Mass Spectrometer Hazardous Gas Systems
- In-situ Pressure Calibrator

CONTACTS

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